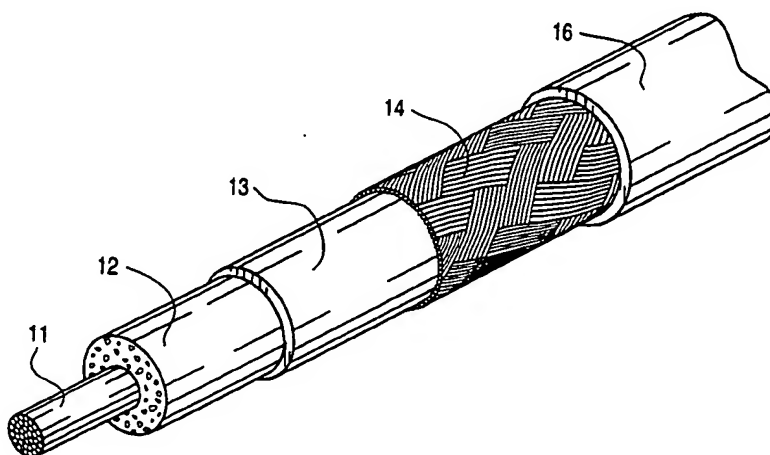




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: <b>PCT/US99/00574</b></p> <p>(22) International Filing Date: <b>11 January 1999 (11.01.99)</b></p> <p>(30) Priority Data: <b>09/006,101</b>      <b>13 January 1998 (13.01.98)</b>      <b>US</b></p> <p>(71) Applicant: <b>SUN MICROSYSTEMS, INC. [US/US]; 901 San Antonio Road, MS PAL1-521, Palo Alto, CA 94303 (US).</b></p> <p>(72) Inventor: <b>DAVIDSON, Howard, L.; 59 Club Drive, San Carlos, CA 94070 (US).</b></p> <p>(74) Agents: <b>CAPLAN, Julian et al.; Flehr, Hohbach, Test, Albritton &amp; Herbert LLP, Suite 3400, 4 Embarcadero Center, San Francisco, CA 94111-4187 (US).</b></p>	<p>(81) Designated States: <b>AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</b></p> <p><b>Published</b> <i>With international search report.</i></p>	

(54) Title: **LOW THERMAL SKEW FIBER OPTIC CABLE**

## (57) Abstract

A fiber optic cable is provided with a thermal shield which consists (proceeding outward from the cable) of a temperature insulating layer of a foam plastic such as polyethylene, a plastic film wrap such as aluminized nylon, a metallic braid such as tinned copper and an outer jacket of plastic as additional temperature insulation and to facilitate pulling the cable. The film wrap and outer jacket are optional. For further shielding a second layer of foam plastic may be positioned outside the first metallic braid followed by a second plastic film wrap, a second metallic braid and an outer plastic jacket. If the shielded cable is near a source of heat, such as a hot water pipe or an air conditioning duct, the fiber optic cable temperature is uniform throughout its cross section. Without the thermal shield instability of the signals in different fibers may occur because of heat differential.

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## LOW THERMAL SKEW FIBER OPTIC CABLE

5

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

10 This invention relates to a new and improved low thermal skew optic cable covered with successive layers of materials in such manner that heat or cold from a localized source is distributed relatively uniformly throughout the fiber optic cable.

#### 2. Description of Related Art

15 The use of fiber optic cables as carriers for electronic signals is well known. Frequently such fiber optic cables are coated with a plastic jacket which not only provides thermal insulation but functions as a slick surface to make it easier to pull a cable through a conduits, etc. The use of metallic braid and the use of a metallized polymer film under the braid are likewise well known in industry; for example, in coaxial cables.

### SUMMARY OF THE INVENTION:

20 Fiber optic cables may comprise several fibers either as filaments or ribbons within a single cable. One of the fibers may provide a clock signal used to recover data at the receiving end. Frequently, such cables are positioned in proximity to a source of heat or cold such as a hot water pipe or air conditioning duct, whereupon one of the fibers or ribbons is at a different temperature than another located farther from the source of heat or cold.

This results in different travel times of data over the different fibers, a phenomenon known as "thermal skew". The present invention reduces thermal skew.

Temperature gradients which may result in differential delay times through different fibers in a multi-fiber cable may be a performance limiter because of temperature differentials  
5 between fibers on opposite sides when the cable is positioned so that one side is close to a source of heat or cold. A principal object of the present invention is to reduce temperature gradients in such structures. Temperature gradients may result in change in length of the fibers and also a change in the index of refraction.

In accordance with this invention, a thermal shield is formed around the core of the  
10 cable. In one preferred form of the invention a layer of foam plastic surrounds the fiber optic core or bundle. A metallic braid such as tinned copper surrounds the foam plastic. To block radiative heat transfer through gaps in the braid, a layer of metalized plastic film may be positioned underneath the braid. As further heat insulation and also to make the cables slick, a plastic jacket may be placed over the metallic braid.

15 In a modified form of the invention a second layer of foam plastic is positioned around the aforementioned metallic braid and the second layer of foam plastic is covered with a second metallized plastic film with a second metallic braid around the outside of the film. Again, a plastic jacket may go over the second or outer metallic braid.

In addition to enhancing radiant reduction, the use of two metallic braids also makes  
20 it possible to use one braid for power and the other for return to operate electronics at the far end of the cable.

Still another feature of the invention is that the use of metallic braids increases the tensile strength of the cable and thus may eliminate the need for Kevlar strength members which are often incorporated into fiber optic cables in order to pull the cable.

25 BRIEF DESCRIPTION OF THE DRAWINGS:

The accompanying drawings, which are incorporated in and form a part of this specification, illustrate embodiments of the invention and, together with the description serve to explain the principles of the invention.

Fig. 1 is a perspective view of a cable in accordance with the present invention with  
30 successive layers cut away to reveal internal construction.

Fig. 2 is a transverse cross-section of the structure of Fig. 1.

Fig. 3 is a view similar to Fig. 2 of a modification.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference will now be made in detail to the preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. While the invention will  
5 be described in conjunction with the preferred embodiments, it will be understood that they are not intended to limit the invention to those embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the invention as defined by the appended claims.

A core consisting of a fiber optic bundle 11 is well known in the electronics industry.  
10 The core is composed of plural discrete filaments or ribbons (herein "fiber optic elements") each of which is adapted to carry an optical signal. For example, one such element may carry a timing signal. The signals transmitted on such bundles are extremely sensitive to time delays such as those caused by one of the elements being heated to a higher temperature than another on the opposite side of the cable. Hence, due to temperature differentials, the  
15 signals may be "skewed".

In accordance with the present invention a buffer layer 12 of plastic foam surrounds the core 11 and provides mechanical thermal insulation. There are a number of suitable foam plastics of which typical materials are foamed polyethylene, foamed TEFLON and foamed polypropylene. Suitable foam plastics are such as are used as the dielectric of coaxial cables.  
20 Suitable cables are Belden 924-8 (cellular polyethylene) or Belden 89880 (foamed TEFLON®, both products of Belden Wire & Cable Co.). Other dielectrics may also be used. Suitable dielectrics have low thermal conductivity and are light and flexible.

A metallic braid 14 is positioned around the outside of the buffer layer. Such a braid may be of tinned copper such as that used to shield flexible coaxial cables. Bare copper  
25 and silver-plated copper are also suitable. A served wrap of wire or metal foil are also suitable. An advantage of the metallic braid is that it gives tensile strength to the cable and makes it possible to eliminate the conventional Kevlar strength member which is frequently incorporated into fiber optic cables.

To reduce the possibility of radiative heat transfer through the small gaps in the braid  
30 14, it is desirable to place a layer of metallized polymer film 13 between the plastic foam layer 12 and the braid 14. Aluminized polyester tape is suitable for such purpose.

An outer jacket 16 is placed over the braid. Such a jacket may be formed of vinyl, polyurethane, TEFLON®, natural or synthetic rubber and other products. The outer plastic jacket 16 provides additional heat insulation but more importantly as is well known in the fiber optic cable industry, it provides an abrasion resistant outer surface which facilitates  
5 pulling the cable through conduits around corners and in other installations.

A source of heat or cold is indicated by the arrow in Fig. 2. This may be a hot water pipe, a very cold pipe or air conditioning duct, or the like. Direct thermal conduction of the heat or cold to the fiber optic cable 11 is isolated by the foam plastic layer 12. The metallic braid 14, being heat conductive, distributes the heat around the circumference of the foam  
10 plastic insulation layer 12. Hence, thermal skew of the fibers in the cable bundle 11 is greatly reduced.

As illustrated in Fig. 3, additional temperature gradient reduction can be obtained by applying a second plastic foam layer 21 around the metallic braid 14, a second (optional) metalized polymer film 22 around the layer 21 and under second metallic braid 23. An outer  
15 jacket 24 similar to the jacket 16 may surround the braid 23.

In other respects, the modification of Fig. 3 resembles the preceding modification and the same reference numerals, followed by the subscript "a", are used to designate corresponding parts.

Using two shields with film radiation barriers provides two stages of radiant reduction.  
20 A second advantage of the use of two metallic braids 14, 23 is to provide power and return to operate electronics at the far end of the cable.

The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications  
25 and variations are possible in light of the above teaching. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the Claims appended hereto and  
30 their equivalents.

WHAT IS CLAIMED IS:

1. A cable comprising a core comprising a bundle of a plurality of discrete fiber optic elements, a layer of thermal insulation around such core, and a layer of heat-conductive material outside said insulation.
- 5 2. A cable according to Claim 1 in which said thermal insulation is foam plastic.
3. A cable according to Claim 2 in which said plastic is foamed polyethylene.
4. A cable according to Claim 2 in which said plastic is foamed TEFLON®.
5. A cable according to Claim 2 in which said plastic is foamed polypropylene.
6. A cable according to Claim 1 in which said heat-conductive material is of the  
10 group consisting of metallic braid, served wrap of wire and metal foil.
7. A cable according to Claim 6 in which said braid is tinned copper.
8. A cable according to Claim 6 in which said braid is bare copper.
9. A cable according to Claim 6 in which said braid is silver-plated copper.
10. A cable according to Claim 1 which further comprises a blocking layer positioned  
15 underneath said heat-conductive material to block radiative heat transfer through said heat-conductive material.
11. A cable according to Claim 10 in which said blocking layer is metallized plastic film.
12. A cable according to Claim 10 in which said film is aluminized polyester.

13. A cable according to Claim 1 which further comprises an abrasion-resistant jacket around said heat-conductive material.
14. A cable according to Claim 13 in which said jacket is of a plastic material.
15. A cable according to Claim 14 in which said material is of the group consisting  
5 of a vinyl, polyurethane, TEFLON, KYLAR, and natural or artificial rubber.
16. A cable according to Claim 1 which further comprises a second layer of thermal insulation outside said layer of heat-conductive material.
17. A cable according to Claim 16 in which said second layer of thermal insulation is foam plastic.
- 10 18. A cable according to Claim 16 which further comprises a second layer of heat-conductive material outside said second layer of thermal insulation.
19. A cable according to Claim 18 in which said second layer of heat-conductive material is metallic braid.
- 20 20. A cable according to Claim 18 which further comprises a second blocking layer positioned underneath said second layer of heat-radiation conductive material to block heat transfer through said second layer of heat-conductive material .
21. A cable according to Claim 20 in which said second blocking layer is metallized plastic film.
22. A cable according to Claim 18 which further comprises an abrasion-resistant  
20 jacket around said second layer of heat-conductive material.
23. A cable according to Claim 22 in which said jacket is of the group consisting of foamed vinyl, polyurethane, TEFLON®, and polyethylene.



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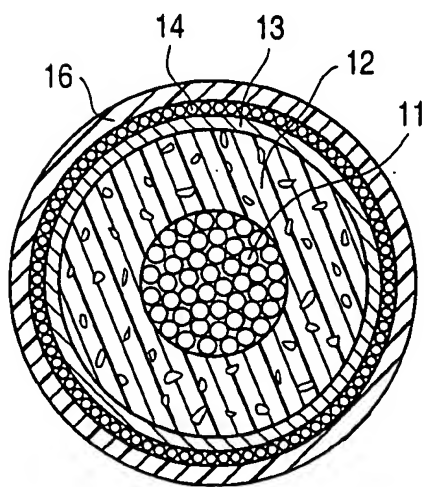
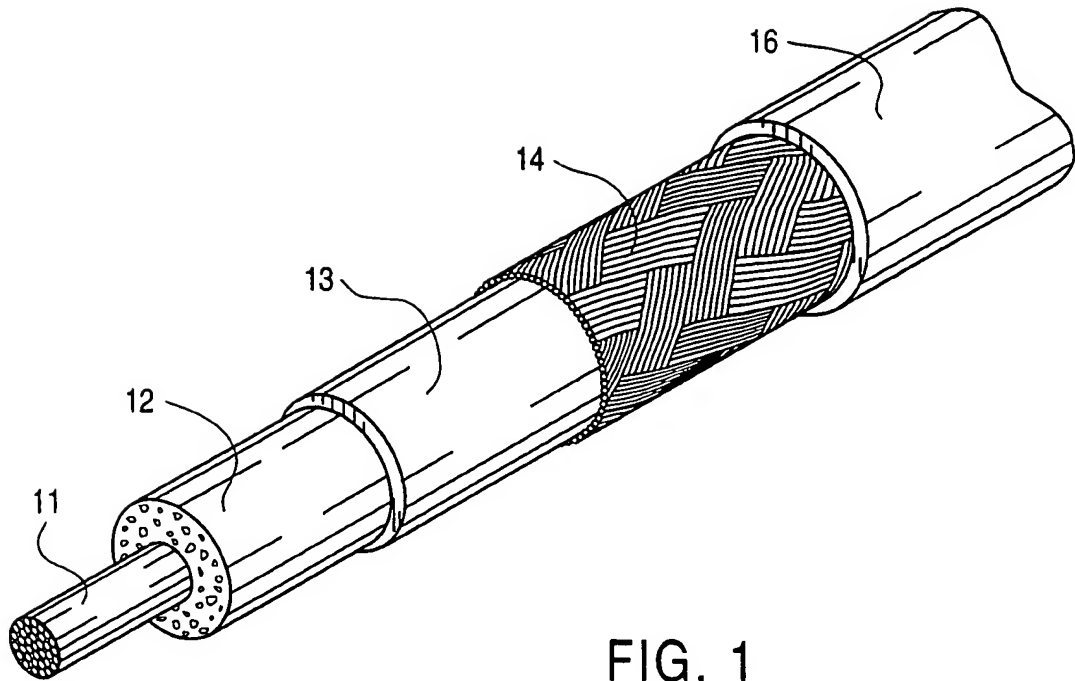


FIG. 2

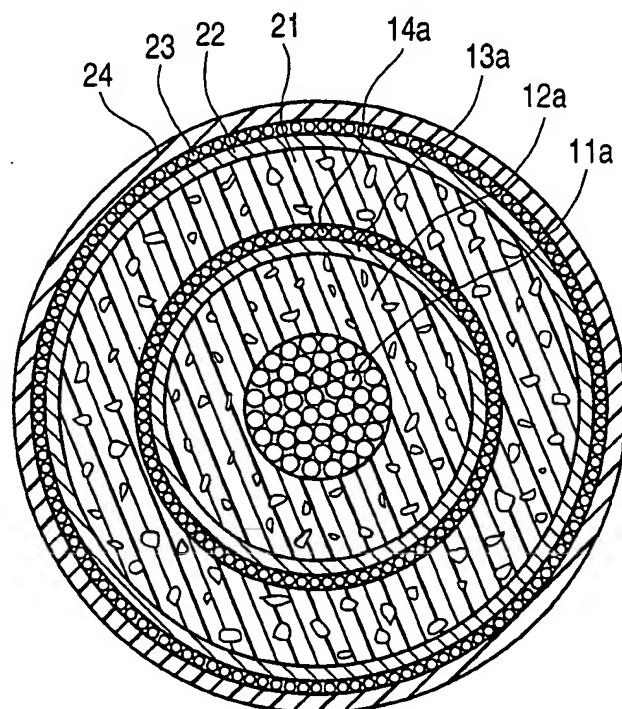


FIG. 3

# INTERNATIONAL SEARCH REPORT

Inter. Appl. No.  
PCT/US 99/00574

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 6 G02B6/44

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	EP 0 345 452 A (TRW EHRENREICH GMBH) 13 December 1989 see claims; figures ---	1,2 6-10,16, 17
X A	US 4 547 626 A (PEDERSEN JACK R ET AL) 15 October 1985 see claims; figures ---	1,6,7, 10-14 15
X	PATENT ABSTRACTS OF JAPAN vol. 014, no. 349 (P-1084), 27 July 1990 & JP 02 126208 A (KUBOTA LTD), 15 May 1990 see abstract --- -/--	1,13

☒ Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 228 (P-1531), 11 May 1993 & JP 04 357427 A (FURUKAWA ELECTRIC CO LTD:THE), 10 December 1992 see abstract	1
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